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QUARRYING AND CRUSHING METHODS AND COSTS AT THE AVON MOUNTAIN TRAP ROCK QUARRY OF THE ATLAS SAND, GRAVEL & STONE CO., WEST HARTFORD, CONN.

BY

JOHN S. DUNNING

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QUARRYING AND CRUSHING METHODS AND COSTS AT THE AVON MOUNTAIN TRAP ROCK QUARRY OF THE ATLAS SAND, GRAVEL & STONE CO., WEST HARTFORD, CONN. [1]

By John S. Dunning [2]

INTRODUCTION

This is one of a series of papers being prepared for and published by the United States Bureau of Mines, describing mining and milling methods at crushed-stone plants throughout the United States. These papers are designed to disseminate technical information regarding the methods used. The cost tabulations represent operating expenditures only and not total production costs. It is recognized that publication of total production costs might in many instances cause embarrassment to individual producers as well as to the industry as a whole. However, operating costs are essential to technical discussion and study of the methods employed. The attention of the reader is specifically called to this differentiation in order that the scope of the cost tabulations shall not be misunderstood.

This paper deals with the quarrying and crushing methods used at the Avon Mountain trap-rock quarry of the Atlas Sand, Gravel & Stone Co., in West Hartford, Conn.

ACKNOWLEDGMENTS

The author wishes to acknowledge the assistance of J. R. Thoenen, senior mining engineer of the U. S. Bureau of Mines, who furnished many helpful references used in compiling this report.

HISTORY

Avon Mountain lies about 8 miles west of Hartford, Conn., and obstructed the natural expansion of that city westward. Thirty years ago a narrow crooked lane was the only route over the mountain, and the road around it was many miles in length.

About 1915 the State began construction of a well-graded road over the mountain, at which time fine trap rock was discovered, and a quarry was opened beside the road at the top of the mountain. Some 10 years later the

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[2] One of the Consulting engineers, U. S. Bureau of Mines.

Avon Quarries Co. was organized and incorporated to develop the property. In 1929 the Atlas Sand, Gravel & Stone Co. bought the quarry. At that time capacity was about 20 to 25 tons of all sizes of crushed stone per hour. Installation of a primary crusher, larger secondary crushing equipment, and shaker screens has greatly increased the capacity, at the same time lowering the labor cost per ton of stone.

GEOLOGY

Avon Mountain is one of the range of mountains that extends in a rough north and south line through central Connecticut. The formation is trap rock. The extrusion of this rock was, generally, slow but sometimes of volcanic intensity. It occurs in a series of flows.

Differences in the crystalline structure (thus, the hardness) of the rock are due to differences in the rate of cooling. Furthermore, the top 10 to 15 feet of each flow of rock was often made somewhat porous due to gases escaping from the mass below. This porous layer has been removed by erosion in many cases.

Fissures and faults occurred in the trap rock as cooling and contraction proceeded. These openings were either filled with a later extrusion of trap or with products of surface erosion.

The particular sheet of trap rock that composes Avon Mountain is of unascertained depth. The top 10 to 12 feet is typically quite broken, due, presumably, to weathering and frost action of the original semiporous trap.

The topography of the top of the deposit is very uneven, gullies 8 to 10 feet in depth being common. This causes great irregularity in the amount of overburden, which averages about 3 feet in depth and consists of a light clay soil supporting, in some places, a heavy forest growth.

PHYSICAL CHARACTERISTICS OF THE STONE

The ledge of stone is composed of a dense, fine-grained, blue trap rock. The stone, which has a specific gravity of 2.95, is very hard and quite brittle. It shatters cleanly in the crusher. A wavy horizontal stratification in the deposit is pronounced, but, from a quarrying standpoint, the most distinctive characteristic of the stone is its broken nature. The ledge is riddled with small cracks and fractures. The small pieces of stone thus formed have been a great inconvenience in drilling, often caving above the bit and making withdrawal difficult and sometimes impossible.

PROSPECTING AND EXPLORATION

This quarry was originally opened during construction of the highway. Since then no part of the ledge has been found that was not suitable for processing. Consequently, no prospecting or exploratory drilling has been done.

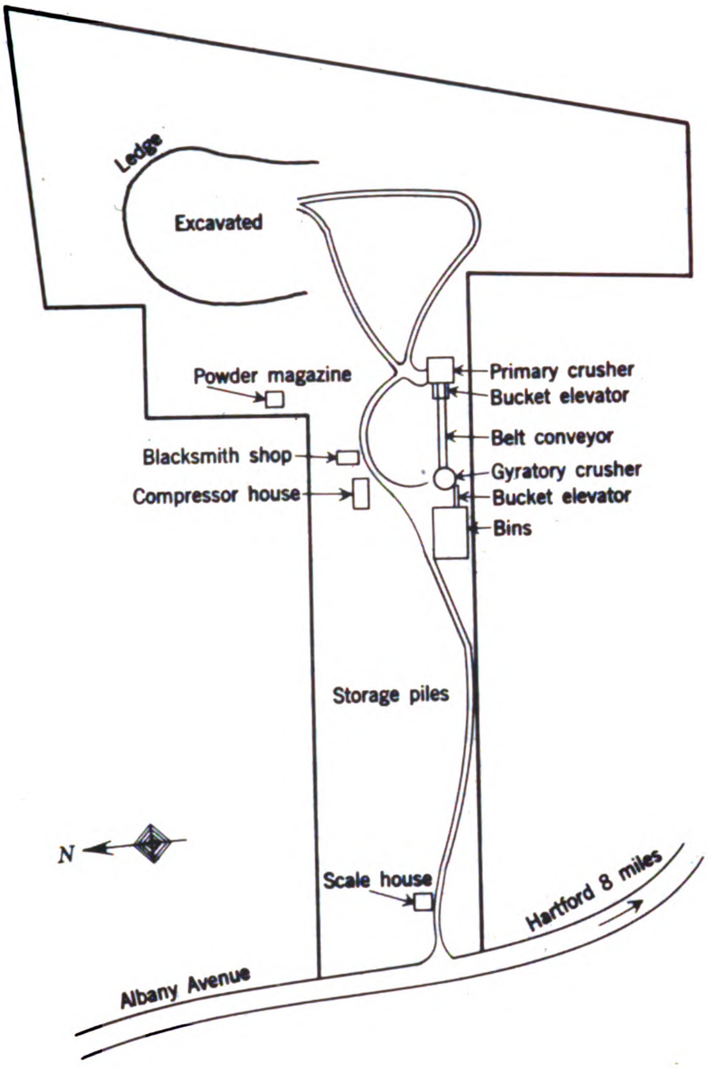

Figure 1.—Sketch of property (not to scale).

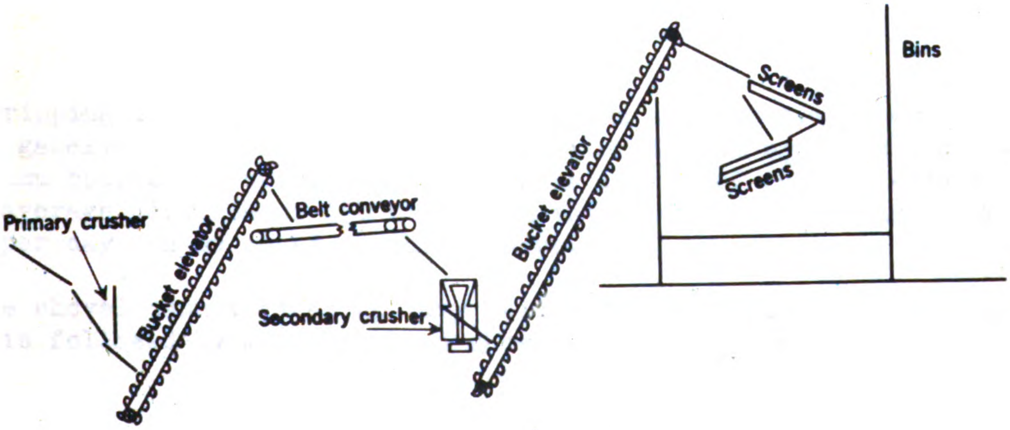

Figure 2.—Flow sheet of plant (not to scale).

SAMPLING AND ESTIMATING

Virtually all of the sampling and testing of this stone has been done by the laboratory of the Connecticut State Highway Department. It has found this stone to be adequate for every type of construction when properly sized.

In planning for drilling and blasting 1 cubic yard of stone in place is calculated to weigh 2 tons.

In controlling production the quarry trucks are often checked on the plant scales, and all records are kept on a tonnage basis, the number of loads to the crushers being multiplied by the average number of tons per load.

CHOICE OF METHOD

With so hard a ledge, blasting with dynamite was the only method considered for the initial breaking. There are three principal local methods of placing the charge of dynamite. Tunneling or coyote blasting was not considered for this quarry because the face was not high enough to justify it. Well drilling (6 inch vertical holes) was not thought to be satisfactory, since the top 10 feet of the ledge was already highly fractured, making recovery easy but drilling difficult. Consequently, the method known locally as "snake holing" was adopted. The amount of overburden and the irregular nature of the top of the ledge made it desirable to do all the drilling and loading of dynamite from the quarry floor. The overburden to be removed averaged about 1 cubic yard for each 18 tons of stone recovered.

The roads throughout the quarry are kept in good, smooth condition because rubber-tired quarry trucks are used. A good deal of trap-rock dust is used on the roads, which are dragged at necessary intervals. The road system is shown in figure 1.

MINING METHODS

Stripping

Stripping is carried on intermittently as a spare-time operation. A ½-yard gasoline-powered shovel and four ton trucks equipped with 2-cubic yard dump bodies are used. The overburden is dumped into a large ravine at an average distance of 150 feet from the present ledge. About 200 cubic yards per day can be moved in this manner.

The shovel cannot clean up very well because of surface irregularity, so it is followed by men with hand shovels and wheelbarrows.

Stripping costs average 27 cents per cubic yard, including the necessary hand work. The overburden has no commercial value.

Drilling

Power for drilling the ledge is supplied through a type XCB compressor, driven by a 75-horsepower electric motor. Two-inch header pipes laid on the ground carry the air to the quarry floor, from which a $1\frac{1}{4}$-inch line leads to the wagon-mounted drill (about 400 feet), where a pressure of 80 pounds is maintained.

Air is used for the drilling in preference to other power, as frequent blowing out of the stone chips is necessary to prevent plugging of the bit in the drill hole.

One and one-quarter-inch hollow round drill steel with lugged shank is used. The drill steel has a 3-foot run with a $\frac{1}{4}$-inch gage change starting at 2-7/8 inches. Drilling is done at a speed of between 40 and 80 feet per 10-hour day and costs approximately 46 cents per foot. Two men operate the drill.

Locating and spacing drill holes are planned with the following points in mind: 1. To get the necessary amount of explosive in the charge, considering height of face and amount of natural breakage in the ledge: 2. To avoid seamy and broken rock that might block the drill: 3. To do the drilling with the fewest possible settings of the drill. The method of drilling three holes at each setting was devised and has been satisfactory.

Normally holes are 20 to 25 feet deep and are blasted with 60 percent gelatin dynamite. Little or no difference has been found in the performance of explosives of similar grades made by different manufacturers. Sticks $1\frac{1}{2}$ by 8 inches have been found to be most convenient. No. 6 electric blasting caps and a hand blasting machine are used.

In springing or chambering, two to three sticks of dynamite are pushed into the hole with a $1\frac{1}{2}$-inch wooden pole spliced with copper to avoid producing sparks. These are detonated electrically to form a cavity to hold the required amount of dynamite. Holes are sprung two or three times, depending on their burden.

Two crews are used in regular dynamite loading. Stone screenings wrapped in newspaper are used for tamping. Special care is necessary to avoid injury to the wires leading into the charge. The average explosive charge is 50 pounds per hole.

For secondary blasting drilling is done with a jackhammer using 7/8-inch hexagon hollow drill steel. Fuse and caps are used to detonate the charge. About 5 percent of the broken stone requires secondary blasting.

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The broken rock is loaded onto 4-ton trucks with a 1¼-cubic yard gasoline-powered shovel. The standard 2-cubic yard dump truck on pneumatic tires and a 2-inch oak-plan lining for the bottom of the body has proved rugged enough for this work. Roadways, as shown on figure 1, are kept cleared of rock and surfaced with screenings as necessary. The average one-way haul is 350 feet.

The quarry floor is kept slightly pitched to facilitate drainage, although, except in the springtime, very little water is encountered.

Figure 2 is a flow sheet of the plant.

The trucks dump directly into a sheet-steel-lined hopper of 5 tons capacity, which directs the rock into a 40- by 48-inch jaw crusher running at 160 r.p.m. and discharging rock 6 inches and under into a chain-and-bucket elevator running at 90 feet per minute, with buckets spaced at 16-inch centers. The crusher is driven by a 150-horsepower electric motor and the elevator by a 25-horsepower motor.

A 36-inch conveyor belt carries the stone 295 feet up a 10° slope to a 48-inch gyratory crusher, which reduces it to a maximum of 2 inches. The conveyor is duplex, having a 32-inch, 6-ply power belt and a 36-inch, 6 ply wear belt. The former has a 1/16-inch rubber cover on each side, while the latter has a 3/8-inch rubber cover on the carrier side and a 1/16-inch rubber cover on the opposite side. It is driven by a 30-horsepower motor through belt and reduction gears from the head pulley. A 75-horsepower synchronous, vertical, direct-connected motor drives the gyratory crusher at 175 r.p.m.

The crushed product is all elevated to the screening tower in an inclined, double-chain, bucket elevator 74 feet long, running on smooth drivers at 120 feet per minute and using 6- by 8- by 20-inch buckets spaced on 12-inch centres. A 40-horsepower motor supplies the power through a flat belt and roller chain.

Separation is effected through two 4-by 8-feet vibrating screens - one three-deck and one two-deck (fig. 2). Each screen is driven by a 5-horsepower electric motor through a 3V-belt drive. The screens are given a rotary vibrating motion against the flow of stone by a counterbalanced, eccentric drive shaft.

The oversize is either drawn directly to trucks and dumped to the secondary crusher or stock-piled for later recrushing.

The sizes of stone produced and the approximate percentage of the total are as follows:

Commercial size	Passes screen size	Retained on screen size	Approximate percent of total
Tailing	--------------	2-5/8 inch square	10
2-inch	2-5/8 inch square	1-5/8 inch square	40
1-inch	1-5/8 inch square	1 inch square	20
$\frac{3}{4}$-inch	1 inch square	5/8 inch square	10
$\frac{1}{2}$-inch	5/8 inch square	3/8 inch square	10
$\frac{1}{4}$-inch	3/8 inch square	3/16 x 3/8 inch slots	5
Screenings	3/16 x 3/8 inch slots	---------------------	5

No washing or drying equipment is used at the quarry. The loading bins which are constructed of wood bolted by 1-inch tie rods, have a capacity of 75 tons each. They discharge through chutes with arc-type, overcut, sheet-steel gates, which are hand operated.

Yard storage is formed by open piles, stacked when necessary and loaded out with a $\frac{1}{2}$-yard gasoline shovel. Trucks are used to dump onto these storage piles.

A machine shop is maintained for routine work. It is equipped with a power saw, power drill, lathe, and small tools. The drill-sharpening shop is equipped with a forge, an oil furnace, and a machine sharpener.

All of the stone broken from the solid is sold except the unavoidable waste in stock-piling and the small amount required for maintaining the quarry roads.

EMPLOYEE PAY SYSTEM

The foreman of the quarry is on a weekly salary. All others are paid at hourly rates ranging from 40 to 55 cents. Although the amount of work depends on sales and weather, yet the crew averages about 10 hours per day and 200 days per year.

SAFETY METHODS

The importance of care and safety is continually emphasized to the men. Fences and guards are carefully maintained at all dangerous locations. An emergency first-aid kit is kept on the premises. Any serious injuries are treated by a local doctor.

The administrative organization of the quarry is very simple. The superintendent establishes policies, which are carried out by the foreman. Because of the small size of the crew, the foreman takes direct charge of all the man under him. An organization chart follows:

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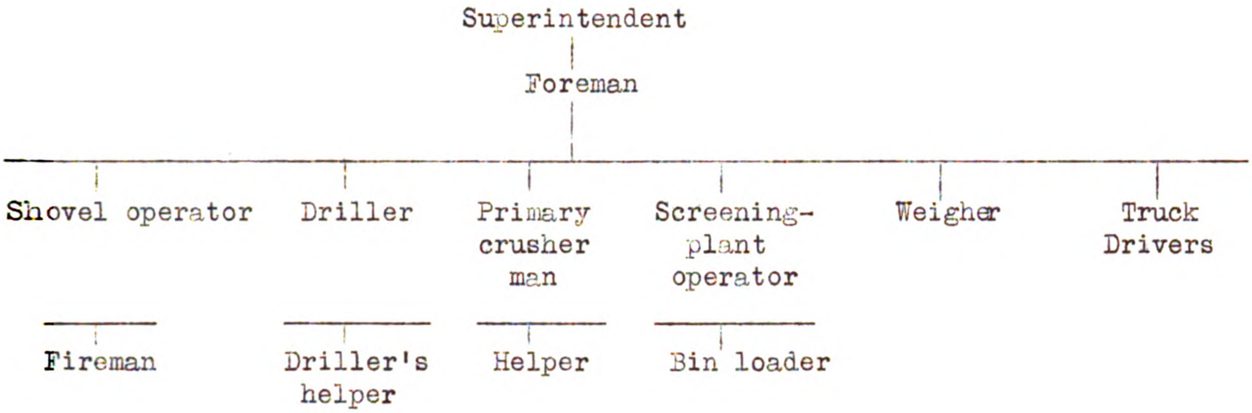

SUMMARY OF COSTS

THE ATLAS SAND, GRAVEL & STONE CO. Jan. 1 - Dec. 31, 1935

Total material loaded during period: Overburden, 3,000 cubic yards (estimated).
Stone, 53,486 tons

	Operating Costs Per Dry Ton Stone Mined							
	Labor	Supervision	Air-drill steel	Power, electric	Fuel	Explosives	Other supplies	Total
Stripping:								
Loading........	$0.003	$0.001			$0.002		$0.006	$0.012
Transportation	.004	.001			.001			.006
Total	.007	.002			.003		.006	.018
Quarrying (ton)..								
Drilling (prim.)	.032	.005	$0.007	$0.036			.012	.092
Drilling (sec.)	.007	.001	.002	.004			.002	.016
Blasting (prim.)	.008	.004				$0.031	.008	.051
Blasting (sec.)	.001	.001				.003		.005
Loading........	.017	.004			.012		.012	.045
Transportation.	.022	.003			.010		.018	.053
Miscell.(scale)	.012							.012
Total	.099	.018	.009	.040	.022	.034	.052	.274
Plant:								
Crushing (prim.)	.024	.003		.026			.007	.060
Crushing (sec.)	.016	.004		.022			.015	.057
Screening......	.007	.001		.003			.006	.017
Elevating......	.004			.010			.012	.026
Conveying......	.002			.004			.015	.021
Storage, in ...	.010	.001			.003		.006	.020
Storage, out ..	.009	.001			.007		.003	.020
Miscellaneous..	.015	.001		.003			.015	.034
Total	.087	.011		.068	.010		.079	.255
Total operating	.193	.031	.009	.108	.035	.034	.137	.547

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